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THE PROBLEM OF SHOCK IN PATHOPHYSIOLOGY AND AT THE CLINIC

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On the basis of I. P. Pavlov's theory, Soviet scientists regard traumatic shock as a manifestation of the inhibition of the nervous system.

N. N. Burdenko has clearly resolved the problem in regard to the development of the state of traumatic shock by stages. In addition to the principal cause of shock, i.e., pain trauma which is brought about by mechanical, thermal, or other irritants, a significant factor in the development of shock is the state of the human organism which is subjected to the action of various supplementary factors. All factors which bring about a weakening of the functions of the central nervous system, i.e., psychic trauma, loss of blood, fatigue, lack of nutrition, lack of sleep, etc., contribute to the appearance of shock. Of some significance in the origin of shock is the type of higher nervous activity, which determines the relation of the organism to changes of the internal and external environment.

Of decisive importance in the development of traumatic shock is a change under the influence of a traumatic injury in the relationship between processes of stimulation and of inhibition in the central nervous system.

Under the effect of the flow of impulses originating by reason of the irritation of exteroreceptors and interoreceptors at the site of the trauma, a stage of the excitation of the central nervous system arises. The cerebral cortex is excited first and the internal inhibition becomes insufficient. This period is characterized by a general state of motor and speech excitation, increased arterial pressure, tachycardia, hyperglycemia, hyperadrenalinemia, short breath, and an increased level of metabolism. The excitation of the cerebrum bears a diffuse character, i.e., it involves the cerebral cortex and the subcortical divisions. The changes which have been mentioned originate under the effect of the corresponding reflexes.

A further flow of impulses, on being added to the prior flow, leads to a weakening and exhaustion of the cerebral cortex, so that an extralimital inhibition appears originally in the cerebral cortex and then in the subcortical region.

It has been shown recently that under the effect of trauma produced by the application of a tourniquet (D. M. Gzgzyan) or of maceration of the tissues of the hind leg of dogs (V. K. Kulagin), phase alterations arise in the conditioned reflexes, i.e., equalizing, paradoxal, inhibitory, and ultraparadoxal phases of conditioned reflexes develop successively.

For the torpid phase of shock, a profound extralimital inhibition of the subcortical region is characteristic. The fact that this inhibition occurs is demonstrated by very faint, shallow breathing, a lowering of arterial pressure, and parabiotic phases of vascular reflexes which have been discovered in recent work by M. G. Danilov and F. P. Markizova, V. K. Kulagin, V. K. Sel'tser, and others.

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In some cases inhibition in the subcortical region does not yet develop in the initial period of the torpid phase of shock, although there is a pronounced translimital inhibition of the cerebral cortex. In such cases, notwithstanding the general depression, the arterial pressure remains unchanged or is even increased because of the elimination of the inhibitory influence exerted by the cerebral cortex.

The acute vascular and respiratory insufficiency which develops as a result of the disturbance of the functioning of the central nervous system leads to a hypoxemia which in turn aggravates the disturbance of the central nervous system. A vicious circle arises: disturbances of the circulation and of the respiration, which result in consequence of the disturbance of the functions of the central nervous system, lead to the development of hypoxemia and hypoxemia in turn increases the dislocation of the functions of the central nervous system. Lowering of the rate of metabolism and disturbance of the normal course of oxidation processes are typical for heavy traumatic shock.

Very little work has been done as yet on the problem of the prophylaxis of traumatic shock and shock resulting from burns. During World War II attempts have been made to organize the procedures for the therapy of shock soon after wounds have been inflicted on the battlefield. These procedures comprised administration to the wounded of special antishock mixtures on the basis of work done by S. I. Banaytis, V. I. Popov, A. A. Vishnevskiy, N. S. Molchanov, and others.

Application of prophylactic measures immediately after a mechanical trauma, wounds, or burns is very important because shock in the majority of cases appears after some time has elapsed since the infliction of the trauma.

Based on a consideration of the diversity of functional disturbances in shock, the prophylactic measures that are applied have the purpose of eliminating the initial changes which result under the effect of shock and aim to prevent a disturbance of the interrelationship between the excitatory and inhibitory processes of the central nervous system as well as changes in the circulation and metabolism.

Starting from these considerations, V. K. Kulagin investigated the action of an antishock mixture consisting of sodium bromide, caffeine, morphine, glucose and vitamines C, B_1, and P, which was administered 30 minutes after the trauma internally to dogs simultaneously with an intramuscular injection of desoxicorticosterone acetate. In the majority of cases, the animals which had received a supplementary heavy trauma did not develop traumatic shock, while traumatic shock as a rule did develop in the control animals and resulted in death.

On the basis of the experimental data obtained we may recommend this method of therapy for use in emergency treatment of counteract shock resulting from trauma or burns.

The successful application of anesthesia, administration of analgetics, and other measures for the prophylaxis of surgical shock are well known. However, these old methods of prophylaxis are inadequate for the prevention of complications in difficult operations such as those carried out in the chest, particularly on the heart. In such cases, strong reflex changes take place in the most important vital functions and oxygen starvation of the brain develops. To alleviate these conditions, more effective methods of preventing shock had to be applied at the surgical clinic.

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One of the newer methods which is being applied is administration together with the anesthetic of oxygen and of curariform drugs. At the same time, "controlled respiration" is applied. This method, which is extensively used in the clinics of A. N. Bakulev, P. A. Kupriyanov, B. V. Petrovskiy, and others, makes it possible to carry out successfully operations on lungs.

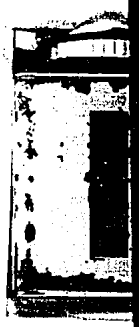
However, these measures are entirely inadequate for the prevention of complications in operations carried out on the heart whenever it is necessary to stop circulation in the heart temporarily. In such operations, and also in operations carried out on debilitated patients, general hypothermia produced by various means is now applied. At present a number of publications by Soviet authors (V. S. Vayl', V. A. Konstantinov, P. A. Arkhangel'skaya, Ye. V. Maystrakh, and others) has appeared in which the increased resistance of the organism to a shortage of oxygen in hypothermia has been confirmed.

When the temperature of an animal or human being is lowered to 31°, 28°, 25°, or 24° C, a profound inhibition of the central nervous system and sharp lowering of the level of metabolism arise. In connection with this, the need for oxygen is greatly reduced. As a result, the resistance of the brain to the effects of afferent impulses from the site of the trauma and to oxygen starvation is increased. The state of the organism which is brought about by hypothermia has been likened to hibernation.

American and Italian authors who have applied hypothermia in experimental work at the clinic explain its beneficial effect primarily by the direct action of the low temperature on the rate of metabolic processes taking place in tissues. French investigators, who apply mixtures of drugs in combination with general cooling, ascribe the principal effect produced by the method to a stabilization of the vegetative nervous system, particularly in its peripheral divisions. In general, foreign investigators disregard the role of the protective inhibition which inevitably arises in the brain under the effect of hypothermia. This inhibition brings about a saving of adenosinetriphosphoric acid in the brain, i.e., of a compound which is subjected to a considerable amount of decomposition during cerebral anemia (K. K. Gromova, T. Ye. Kudritskaya, V. S. Shapot).

At present, hypothermia is used in the clinic in connection with surgical operations carried out on the heart and in connection with difficult operations to which debilitated patients must be subjected. However, according to data obtained abroad, a high rate of mortality results from some operations on the heart. Investigations on the subject are also being conducted in the USSR, i.e., at the clinics of A. N. Bakulev and B. V. Petrovskiy in Moscow and at the clinics of V. N. Shamov and P. A. Kupriyanov in Leningrad. In experimental investigations carried out by both foreign and USSR scientists (V. I. Burakovskiy, Ye. V. Gubler) it was possible by applying hypothermia in combination with anesthetics to stop the circulation in the heart for 15-18 minutes and sometimes even for 19-20 minutes by tying up the vena azygos and placing clamps on the vena cava inferior and the vena cava superior.

In the opinion of all investigators, the cause of the high mortality in the experiments must be ascribed to a fibrillation and acute weakness of the heart which arises during the time of the stoppage of circulation and after removal of the clamps from the veins. Our investigations show that application of hexonium (a ganglia-blocking substance synthetized in the USSR) together with hypothermia and with ether-oxygen anesthesia prevents the early onset of fibrillation and of weakness of the heart. Of importance for the prevention of these complications is a certain order of placing the clamps on the venae cavae and of their removal. The clamps must be applied first to the vena cava inferior and at the expiration of a minute to the vena cava superior. The clamps are removed in the reverse order. At the same time a light massage of the heart is carried out. This order



of placing the clamps on the veins creates a stoppage of the flow of blood in the posterior half of the body and prevents a stoppage of the circulation in the brain. Removing the clamp from the vena cava superior first prevents the possibility that the heart may expand and become weak as a result. The clamps must be removed gradually from the veins.

Using the method outlined above and applying preliminarily introduction into the blood of glucose and vitamins C and B_1, we succeeded in stopping the circulation in the heart for 22-25 minutes with complete restoration of the animals to a normal condition subsequently to that.

The years of World War II were marked by important achievements in the treatment of traumatic shock on the basis of Pavlov's teaching. This work was carried out by E. A. Asratyan and others. They formulated the basic principles of the comprehensive therapy of shock. An effective therapy of shock must comprise measures which bring back to normal the processes of excitation and inhibition in the central nervous system and stop the flow of pain impulses from the site of the trauma. These measures must also eliminate oxygen starvation and bring the metabolism back to normal. The principles involved here have not lost their significance at present. The comprehensive therapy which is applied includes administration of anesthetics which reinforce the protective inhibition. Among the anesthetics that are used one of the best is hedonal. For the same purpose, the antishock liquids of Popov, Sel'tsovskiy, Asrat'yan, Fedorov, and Filatov and the alcohol-bromide-glucose liquid of Petrov are recommended.

Sedatives and hypnotics [literally "narcotics"] should be used in shock only in small doses which produce sleep; when these drugs were used experimentally in large doses producing anesthesia [literally "narcosis"] an unfavorable course of the shock was found to occur.

To reinforce the inhibition processes exerted by the central nervous system, it is expedient to use bromides both separately and in combination with other drugs, i.e., alcohol, glucose, and anesthetics. It is advisable to add caffeine to bromides. Novocain is universally used in cases of shock because it eliminates the flow of pain impulses.

To stop oxygen starvation, measures are used which bring the circulation and respiration to normal, i.e., blood transfusion, transfusion of blood substitutes, transfusion of solutions of dry plasma, and inhalation of oxygen.

In cases of acute shock, a good therapeutic effect is obtained when large quantities of blood (750-1000 milliliters) are transfused. Encouraging results in the treatment of experimental shock and of shock under clinical conditions were obtained by applying as one of the measures of comprehensive therapy the administration of new blood-substitute solutions prepared at the Leningrad Institute of Blood Transfusion.

Of great practical importance is the prolonged application of oxygen therapy in shock. This therapy is continued for several hours and is being introduced to an increasing extent.

To bring the tissue metabolism back to normal, it is advisable to administer repeatedly the vitamins C, B_1, and P. The problem of using in clinical practice such substances as adenosinetriphosphoric acid, the application of which has yielded good results under experimental conditions, should attract the attention of investigators.

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The achievements which have already been made do not reduce the necessity of conducting further thorough investigations dealing with methods of the prophylaxis of surgical, traumatic, and burn shock as well as with the possibilities of perfecting the methods to be applied in the therapy of shock.

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